THE BREEDING BIOLOGY AND ETHOLOGY OF THE GREEN-TAILED TOWHEE

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by

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Abstract

The ecology study pertained to the breeding biology and behavior of the Green-tailed Towhee (Chlorura chlorura). The species is a summer resident of the mountain shrub belt of the foothills and mountains of the western states. It winters in southern portions of California, Arizona, Texas, as well as central Mexico.

The area studied is located 15 miles east of Salt Lake City, Utah in the Wasatch Mountain range, at an elevation of 6,000 feet. This area was "good" towhee habitat, with low shrubs growing among the many wild flowers and grasses. In this habitat male Green-tailed Towhees established their territories which were maintained by territorial song. The average size of a territory was 9,700 square feet, thus approximately 147 yards by 215 yards.

Males, while migrating to their nesting grounds establish, toward the latter part of the migration, pre-territories. These are loosely formed areas chosen at resting spots. This behavior seemingly leads to rapid territorial establishment when they finally arrive on their permanent nesting grounds.

Although the sexes are indistinguishable to the eye, measurable differences were found in study skins. The wing of males averaged 77.4 mm, while females averaged 74.5 mm. Tail lengths were 83.2 and 80.2 mm respectively.

Pair bonds are formed shortly after the female arrives at the nesting grounds, approximately 2 to 3 days after the male. The bond is for one season. After mating, the female performs all the

nest duties, entailing selection of nest site, construction of nest and incubation of eggs. The male merely patrols his territory.

Normally, only one clutch of eggs is laid and one brood of young raised. If some disturbance leads to abandonment of a nest or if young are destroyed in early developmental stages or are taken by predators, renesting occurs.

Ten nests were located during a two year period. All were placed in sagebrush (Artemisia tridentata Nutt.). The average height of the nest above the ground was 46 cm from rim of cup to the ground

The eggs were laid on consecutive days with an average clutch size of 3.3. Incubation period was 12 days. The young are altricial when hatched and are covered with a dark, sparse down.

The activity of the male in proclaiming his territority markedly decreases as construction of nest, egg laying and incubation are consummated. However, in contrast to the early indifference toward the nest and eggs during the nestling period, the male takes an active part in feeding the young and in cleaning the nest. Both parents are coprophagic of the feces of the young, in other words, disposing of the fecal sacs by ingesting them.

Nestlings fledge after 10 days in the nest. Fledglings are cared for by both parents for an undetermined length of time. They were fed insects. On a year-round basis, the diet of adults is mixed, 57% animal material and 47% plant.

Reproductive success is influenced largely by predation on the

young while in the nest. The predation in the study area was high. Only three of the ten nests observed produced young that fledged. Five were lost to predators. The principal predator seemed to be the magpie (Pica pica (Linnaeus)). Other mortality pertained to one being abandoned because of inclement weather and one was abandoned seemingly because of the observer's presence.

There are certain lines of evidence that support the placing of the Green-tailed Towhee in the genus Pipilo, namely coprophagy, the juvenal plumage, flight patterns, type of habitat chosen, and feeding patterns which are all very similar to the Rufous-sided Towhee.

Introduction

During the past 132 years the Green-tailed Towhee Chlorura chlorura (Audubon, 1839) has had eight different generic names, and today is placed in a monotypic genus. Of evolutionary concern is the relationships of this bird to the other towhees placed in the genus Pipilo Vieillot. Sibley (1955), Parkes (19537), and Dawson (1923) have advocated placing the Green-tailed Towhee in the genus Pipilo, but in evaluating the evidence for doing so Norris (1968:548) stated, "I feel that additional characteristics, such as skeletal and other anatomical features and types of behavior, need to be investigated before students can best piece together, on the basis of all the potentially available, neontological evidence, the phyletic relationships in the towhee group. Only then can the best possible natural classification be achieved." It was with this problem in mind that the present study was undertaken, i.e., to study the ecology and behavior of the Green-tailed Towhee with the hope of aiding the taxonomist in determining the true position of this towhee.

Because the Green-tailed Towhee had never been studied in detail, many basic problems were treated in this study. The purposes of this study were to provide a description of the habitat; determine territorial relationships and give descriptions of territories and territorial behavior; and to determine sexual relationships such as the nesting behavior, incubation and hatching of eggs, care and development of the young and reproductive success.

Materials and Methods

The study was made primarily during the breeding season of 1970 and casually during the same period of 1969. Observations were made from burlap blinds with a 20 power spotting scope and 10 x 35 binoculars. In making the study the birds were observed in their natural habitat during two summers and notes were taken on their daily activities. Individuals were followed, their movements recorded and territorial size established. Information was obtained on all phases of the nesting cycles with particular attention being paid to location of nests. Whenever possible, measurements (weight, width, depth) were taken on the nests and young. Weights were taken using a triple beam balance that weighed to the nearest tenth of a gram. Widths and depths of nests were made using a standard meter stick. Egg measurements were made using dial calipers reading to the nearest tenth of a millimeter. Specimens were collected at intervals during the breeding and nesting season to ascertain breeding condition. Nest and eggs were also taken when there was no interference with the normal breeding cycle. Only abandoned eggs were taken.

For analysis of sexual dimorphism external measurements of the wing, tail, tarsus and bill, from nostril to tip, were taken of all museum specimens using dial calipers reading to the nearest tenth of a millimeter. The standard T-test was used in the statistical analysis of these measurements (Robert, Steel and Torrie, 1960).

The percent of ground area covered by litter, bare soil and

living cover was estimated from two transects 65 meters long with quadrats one-half meter square being sampled every 5 meters (Phillips 1959:29). There were 13 quadrats in each transect. Heights of the shrubs crossed by these transect lines were measured.

Study Area

The area studied is located 15 miles east of Salt Lake City, Utah in Mountain Dell Canyon, Wasatch Mountain Range. The precise location is at a latitude W. 40° 50", longitude W. 111° 40' 55", in section 36 of T 1N and R 2E of Salt Lake County (Mountain Dell Quadrangle, 1962). The elevation ranges between 5,840 and 6,000 feet. The area is on the northwest side of the canyon which has a slope of approximately 25°. The surface is marked by two rather large gullies which run north and south and terminate in the essentially flat bottom of the canyon. The study area is flanked on three sides by highways. The north border is highway 65 and the east border is highway 239. Figure 1 shows the general configuration of the area.

Vegetation

The most obvious characteristic of the vegetation of the study area was that no plants were observed that exceeded 3 meters in height, and most were under 2 meters. The predominant shrubs were bitterbrush (Purshia tridentata (Pursh)DC.) and big sage (Artemisia tridentata Nutt.). Neither excluded the other and at times w were found growing together.

During the spring and summer the area was a virtual flower garden with a carpeting of penstemon (Penstemon cyananthus Hook.), sego lily (Calochortus nuttallii Torr.), big leaf balsamroot (Balsamorhiza macrophylla Nutt.), arrow leaf balsamroot (Balsamorhiza sagittata (Pursh)Nutt.), mountain dandelion (Agoseris

heterophylla (Nutt.) Greene), lupine (Lupinus spp. L.), bitterbrush (Purshia tridentata (Pursh)DC.) and big sage (Artemisia tridentata Nutt.). For other plants in study area see Appendix A.

With the approach of autumn many plants of the area die and the ground between the thickets of bitterbrush and sage becomes covered with litter, leaving little or no bare soil exposed. In the spring these dry plants serve as nesting material for the towhees. Spring ground cover is shown in Table 1. The litter cover constitutes 51%. This represents the average for 26 quadrats in two transects. Thus, there is ample litter for nest construction within a short distance of each nesting site.

Table 1. Spring ground cover

Living	Soil	Litter
37%	12%	51%

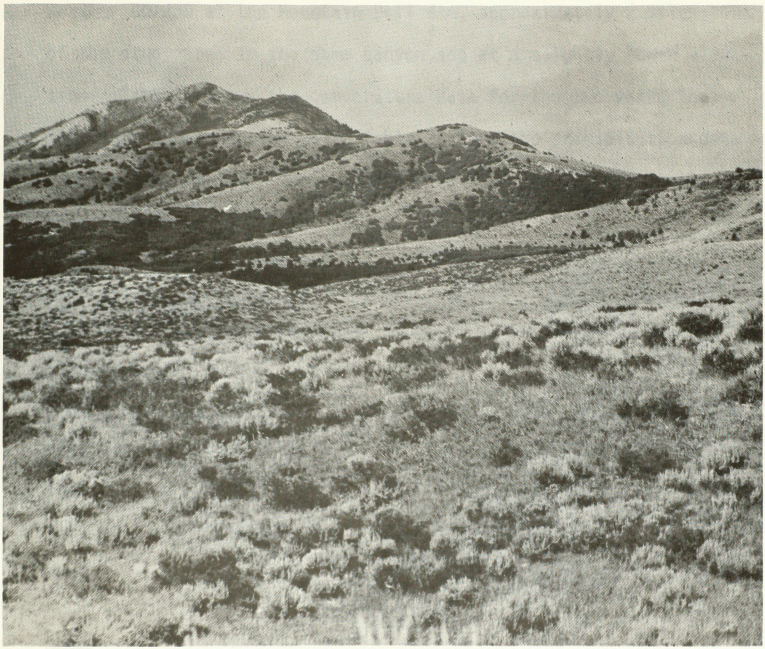


Figure 1. Configuration of the general area studied with towhee habitat shown in the foreground.

Climatological Data

Climatological data is cited because of the critical effect temperature and precipitation has on the nesting Green-tailed Towhee. The data were taken from records attained by the U. S. Weather Bureau at the Mountain Dell dam, approximately 2 miles south of the study area in the same canyon and at a slightly lower elevation. Table 1 shows the temperature data for the two years that the study was conducted while Table 2 shows the precipitation data for the same period. These tables also show averages for a 10 year period for 1951-1960.

Table 2. Temperature Data

Month	Av. Temp. °F	High	Low	1951-1960 Av.
1969				
May	58.6	88	33	53.4
June	58.1	88	35	60.8
July	68.9	93	27	68.9
August	70.1	101	42	68.0
1970				
May	No Report			
June	68.8	97	26	60.8
July	69.5	94	40	68.9
August	70.7	95	45	68.0

Nesting occurs during the months of May and June with second nestings in July. The average temperature does not exceed the low 70's but some of the daytime temperatures reach the high 90's. Also extremely low temperatures are experienced at times during the nesting period.

Table 3. Precipitation Data (in inches)

1969

Month	Total	Greatest Day	Date	1951-1960 Av.
May	.35	.22	15th	2.20
June	4.34	1.69	25th*	1.38
July	.93	.92	29th	.75
August	.76	.64	17th	.95

*June 25th is during the peak of the fledging period.

1970

May	No Report			
June	2.27	1.26	9th*	1.38
July	1.31	.72	21st	.75
August	.55	.32	5th	.95

*June 9th is during the middle of incubation. One nest was abandoned during this storm.

During the two years of study more than normal amounts of precipitation fell during critical periods in the nesting cycles.

Description of Species

There are published descriptions (Norris, 1961) of the Green-tailed Towhee but most deal with or are taken from museum specimens. This description is based on field observation and thus will be helpful in field identification.

Field Identification

The adult coloration and markings are the same for both sexes. The species has a conspicuous chestnut crown which starts at the forehead and extends to the nape. The forehead and the posterior half of the superciliary line are a light gray with slight tinges of green. The anterior half of the superciliary line is white. There is no definite eye ring, but the feathers around the eye present a whitish gray appearance. This arises from the center of the vane of the feathers near the shaft being white with the margin light gray. This same color pattern extends to the auriculars. Below the eye, a white mustachial stripe is separated from the white chin by a light gray line. The pattern of a white superciliary line and mustachial stripe gives the appearance of a cross when one looks directly into the face of the towhee. When in the field this is of little diagnostic value at great distances but most Green-tailed Towhees are seen at close distances as they are flushed or when they are feeding in the low brush. This characteristic is also useful when one approaches a nest. The white cross can be spotted from some distance when the female is looking out from the nest.

In examining specimens in the collection of the University of Utah, all have a gray-green back with dark gray-green primaries and secondaries while the tail is olive. The leading edge of each primary and secondary is olive green, and the bend of the wing is a consistently bright yellow. The major portion of this yellow can only be seen when the bird is in flight. The breast and sides are light gray with the flanks being pale brown. The belly is mixed white with light gray extending in from the sides. The under tail coverts are pale brown. The color patterns are coordinated in such a way as to make this a very handsome bird

Field identification based on coloration and markings is difficult at long distances but different profiles or position assumed by the singing and feeding bird can by helpful in making an identification. Figures 2 and 3 show the adult in two of its most often observed poses. Figure 2 shows the bird searching for grubs. One must be fairly close to observe this action but it is characteristic of the bird. Figure 3 shows the adult male singing. This is the most commonly seen pose assumed by the male. The fluffed feathers and the puffiness of the throat with the head projecting stiffly toward the sky are characteristic. Another feature that helps in field identification is its characteristic flight pattern. The bird never flies at heights above 3 meters and most of the time it flies less than a meter above the brush. These flights are usually for short distances of 10 to 15 meters. When making these

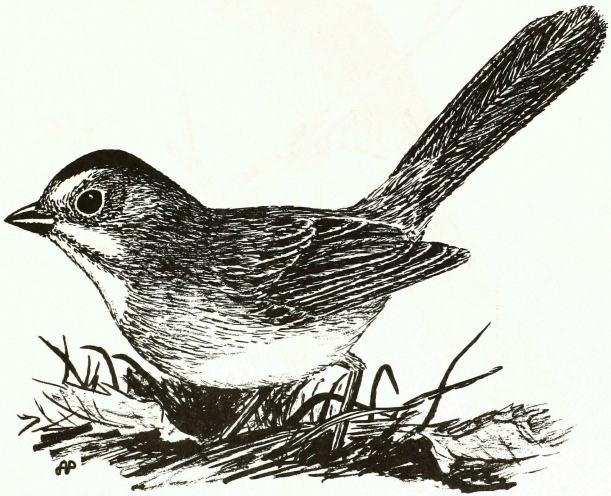


Figure 2. Adult Green-tailed Towhee in feeding posture.

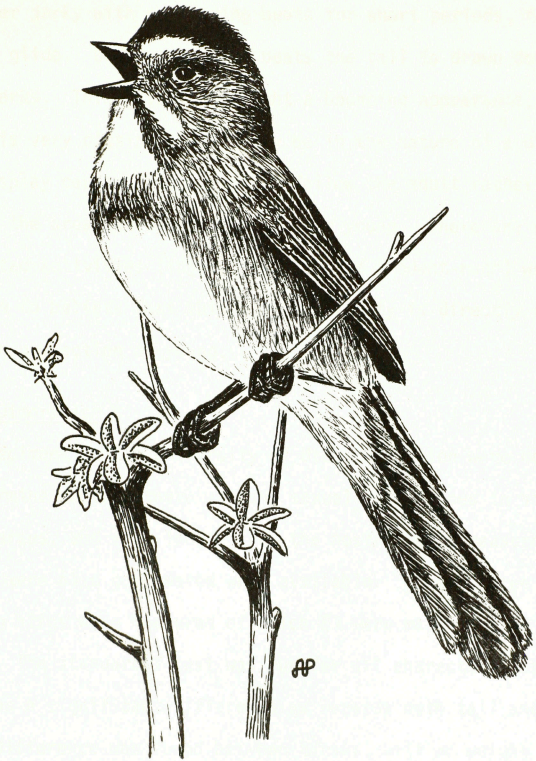


Figure 3. Male Green-tailed Towhee singing posture.

short flights the bird makes a wagging motion with its tail. This is similar to the motion made by Pipilo erythrophthalmus. The flight is rather jerky with rapid wing beats for short periods, followed by a short glide. During the wing beats the tail is drawn down in short jerks. This gives the flight a bouncing appearance. This motion is very distinctive and may be in the nature of a distraction display causing a predator to follow the adult rather than remain in the area and locate the nest or young. There are other associated activities (injury feigning and "rodent-run") which cause me to believe that this flight activity is directly correlated with protection of young.

Sexual Dimorphism

Specimens in the University of Utah collection were measured to determine whether there are any sexual differences in size. Wing, tail, tarsus, and bill length from the nostril were measured, and weights were also considered when available. Ninety-three adult breeding birds were measured of which 53 were males and 43 were females. The standard T-test was run for all characters measured. There was a significant difference as regards both tail and wing but no difference was found between tarsus, bill or weight (see Table 4). The males have longer tails and wings than females. This size difference may be correlated with protection of the more exposed male. He is out in the open more than the female and long wings presumably have some advantage by giving more power in

flight (Van Tyne 1966:197).

Table 3. T-test on male and female Green-tailed Towhees. A significant difference is shown between males and females on wing and tail measurements.

Males

	N1	MEAN	SD
Wing	53	77.5	2.1
Tail	53	83.2	4.3
Tarsus	53	25.2	8.2
Bill	52	8.7	.4
Weight	17	29.0	1.4

Females

	N2	MEAN	SD
Wing	40	74.6	2.6
Tail	40	80.2	3.8
Tarsus	40	23.8	.7
Bill	40	8.7	-.4
Weight	16	29.4	2.0

Males and Females

	T-VALUE	DF	PROB
Wing	5.7	91	1.00
Tail	3.5	91	.99
Tarsus	1.1	91	.85
Bill	-.4	90	.35
Weight	-.6	31	.27

Figure 4. Runways and flyways through brush used by the Green-tailed Towhee.

Habitat and Ecologic Niche Relations

Habitat

The habitat requirements of Green-tailed Towhees have never been studied in great detail, although many authors have made casual comments on some of the more obvious aspects. (Storer (1933) noted that the Green-tailed Towhees were favored by the altered condition of the California forests, that is, where the trees had been removed and replaced by chaparral. Attwater (1892) observed that they frequented thick underbrush, scratching about in the leaves. The main characteristic of the towhee's habitat is the lack of trees, few being tolerated. If any are present, they are used by the males for song posts. The tallest vegetation in the area I studied was 24 feet, and consisted of a single tree. The majority of the vegetation was under 2 meters, with bitterbrush (Purshia tridentata) being the tallest shrub with an average height of 116.8 cm. The height of these bushes ranges from 76 cm to 151 cm. Sagebrush was the next tallest plant with an average height of 863 cm and a range of 45 cm to 119 cm.

The next most obvious aspect of the habitat were the "runways" through the brush. These consisted of open spaces between the thickets. Usually the ground is not bare, but is covered with grass and annual flowers (see Figure 4). Towhees fly close to the ground and sometimes run through the ground cover within these spaces between the bushes. This feature allows the bird the maximum amount of area in which to move and still be protected by the canopy of the surrounding vegetation.

Food

The food habits of the Green-tailed Towhee are related to the time of year and the availability of food. During winter months they may frequent feeding tables and accept chick feed, cracked corn, bread crumbs, and bird seed. Many have been caught in traps set for small mammals. Some observers believe that this happens because of their liking for rolled oats placed on the traps (Grinnell and Storer, 1924). Hayward (1945) noted that Green-tailed Towhees experience a post-nesting updrift (birds moving to higher elevations) and that one reason for this was ripening of foodstuffs at higher elevations at later times than in the nesting areas. This upward movement remains to be corroborated, but the evidence of such movement seems good in the area that I studied.

During nesting, great amounts of food must be fed to the young. My observations of feeding were made from a distance of 100 feet with a spotting scope. Thus, detailed identification of food items was impossible, but all materials brought to the nest seemed to be animal in nature, most being grubs, worms and insect larvae uncovered by scratching. The adult bird eats parts of the animal brought to the nest.

Bryant (1911) examined two stomachs of adults and found them to contain 71% animal food and 29% plant. The animal parts consisted of large and small beetles. The plants were weed seeds. Since the birds eat grubs and worms which are readily available in the litter in which they scratch, it would be expected that the

percent of animal food in their diet would be much higher because the grubs eaten would be scarcely recognizable once cut up and partly digested. In stomachs that I examined, only fragments remained. Small beetles and weed seeds, with portions of grubs were found. Rivers (1941) stated that towhees were feeding on third-Instar Mormon crickets. Huey and Travis (1961:626) saw one adult with an insect in its beak. Kalmbach (1914) stated that 35% of the towhee's diet consisted of alfalfa weevils in Utah. Also, ground beetles, darkling beetles, Hymenoptera, and bugs were important animal food items, while vegetable food consisted predominantly of weed seeds. Insects formed 57.5% of the monthly food. From all this information it can be concluded that towhees have a mixed diet of plants and animals with a slightly greater proportion being animal matter.

Enemies and Hazards

Little information on the enemies of Green-tailed Towhees is found in the literature. Inferences have been made that they are preyed upon by coyotes or other mammalian predators (Miller, 1951). From unpublished notes of three students of raptors, I found evidence of extensive predation on Green-tailed Towhees by raptors. Clayton M. White and Richard D. Porter found remains of Green-tailed Towhees at the eyries of the Peregrine (Falco peregrinus Tunstall) in Utah. The late Gary D. Lloyd found four nests of the Red-tailed Hawk (Buteo jamaicensis (Gmelin)) that contained Green-tailed Towhee remains. In one, remains were found on two different occasions. He

also found remains at five Cooper's Hawk's nests (Accipiter cooperii (Bonaparte)); one Sparrow Hawk nest (Falco sparerius Linnaeus); and one Long-eared Owl's nest (Asio otus (Linnaeus)).

Table 4 presents my data on the predators of the Green-tailed Towhee. The number of times towhees were taken and the dates when the remains were found are also shown.

Table 4. Predators of the Green-tailed Towhee.

	Nest number	Dates
Red-tailed Hawk	5	June 24, 29
	9	July 19
	12	July 10
	13	July 9
Cooper's Hawk	1	June 30
	2	July 29
	3	July 15, 18, 30
	5	July 11, 18
	7	July 22
Sparrow Hawk	1	
Long-eared Owl	3	June 11, 20, 23
Peregrine	1	

It is evident from these data that Green-tailed Towhees are heavily utilized by some raptors, especially Cooper's Hawks. In my observations during the summer of 1970, some hawks were seen in or near the study area but no intraspecific action was observed between the towhees and the hawks. For common birds in the study area see Appendix B. Also, there was no evidence that adult birds

were taken after territories were established. The vulnerability of the male towhee to predation from the air is great because he sits exposed on his song post most of the morning and the song post is usually one of the most elevated places in his territory.

While I did not observe any loss of adults to predators in the study area, the loss of nestlings was high. It is a distinct possibility this was due to magpies (Pica pica (Linnaeus)). Before the major portion of the towhees had hatched, young magpies were ready to leave the nest, and shortly after the hatching of the towhees, the young magpies were out of the nest and beginning to hunt for food. They would fly with adults from bush to bush. Any movement or calling of the adults or young towhees would disclose the position of the young. I observed that when magpies came close to the nest the adults would fly at them squealing and mewing. A similar reaction was reported by Davis (1960:453 for the Rufous-sided Towhee (Pipilo erythrophthalmus (Linnaeus)) toward the Scrub Jay (Aphelocoma coerulescens (Bosc)). "The appearance of a jay near nest 2 always evoked loud and steady calling by the male. If the female was not on the nest she would join her mate, both birds calling loudly and rapidly as they moved about, keeping near the jay until it left the area." Collings (1930:155) reported that the European magpies' diet contained 3.5% young birds and 5.5% eggs of wild birds. More information is needed to ascertain to what extent nestlings are preyed upon in this country by magpies and mammalian predators such as the long-tailed weasel (Mustela frenata Lichtenstein) and the striped skunk (Mephitis mephitis (Schreber)) and the

spotted skunk (Spilogale putorius (Linnaeus)), which were abundant in the area. For other mammals found in the study area see Appendix C.

The only reptile observed in the area studied was the Mormon Racer (Coluber constrictor mormon Bairdard and Girard) which is reported to have a diet consisting mainly of insects (Woodbury 1931:73). The Rufous-sided Towhee is sometimes preyed upon by the King snake (Lampropeltis yetulus Schlegel (nec Linne)) in California (Davis 1960:454). The greatest reptilian predator probably is the gopher snake (Pituophis catenifer deserticola Stejneger).

Green-tailed Towhees nest close to or on the ground; this places the nest and young in a position susceptible to mechanical mishaps. Larger, non-predatory animals such as mule deer (Odocoileus hemionus (Rafinesque)), elk (Cervus canadensis Erxleben) or domestic cattle could step on the nest or walk through the thickets which contain the nests. With the advent of the all-terrain vehicles towhees are in even greater danger. While most range animals would tend to walk around brush when not pursued by man, cyclists and jeepsters have been seen to drive right through brush. Specifically, while I was observing birds in the study area three cyclists drove through with no regard for vegetation or animal life.

The main mortality factor other than mechanical destruction is inclement weather. Birds that breed in the upper transition zone, as does the Green-tailed Towhee, often are subjected to

sometimes damaging spring storms. One nest being studied was abandoned because of a sudden hail and rain storm on June 10, 1970. Huey (1936) observed a similar happening in Arizona. "Later, on July 19, a member of our party found a nest containing two eggs. This nest was left undisturbed for the bird to complete the set; but was destroyed by a severe hail storm the next day."

Distribution

The present study was made in the center of the breeding range as described in the A.O.U. checklist (5th ed., 1957:578). It is not known where the birds from the study area winter.

Migration and Pre-territorial Behavior

The Green-tailed Towhees migrate slowly. Cooke (1914:351) stated that the 1,000 mile trip from the wintering home to the breeding grounds in the north may take two months. Early migrants arrive in northern Utah as early as May 3, with the peak arrival being about May 15.

During migration, they travel singly or in small groups of a dozen or so individuals. Toward the latter part of this migration they commence their territorial behavior. This was clearly established on May 8 and 9. On the first day several males were noted feeding and resting in the study area. They were distributed in definite but loosely formed territories, spaced at regular intervals. They sang from song posts, but there were no intraspecific reactions, such as fighting or chasing. On the next morning, May 9 there were no towhees in this area. They had apparently migrated further north during the night. Thus, the "territories" of these migrants were not the same as the true territories of the summer resident population and might be termed pre-territories to differentiate them from later true territories.

Territorial and Sexual Relations

The first males that were summer residents of the study area arrived on May 17. They spaced themselves territorially immediately and proclaimed their territories with song, which continued most of the day. They chose one or two song posts and alternated songs from these and with adjacent males. The females arrived May 19.

Establishment of Territory

As noted, the male establishes the true breeding territory soon after arrival on the breeding grounds and curiously, I saw little fighting or intraspecific action at this time. This may be correlated with the feature of pre-territories being established at resting points toward the latter part of their migration. By establishing pre-territories for short periods of time, the males may have become physiologically and behaviorally prepared for later rapid territory establishment, thus alleviating the emphasis on fighting which is more evident in many other species of Passeriformes.

Territorial Song

The territorial boundaries were maintained by the constant singing of the males. The territorial song is a prominent feature of the male's activity. On rare occasions females break into song. The male used song from the day he arrived in the territory until the post-nesting period. Shortly before dawn a male would ascend to the top of a song post in his territory with his head held high, his chin puffed out and his body held stiff, and sing

with a rapid, wheezy sequence, sup-se-tew-si-se, or eet-ter-te-te-te-si-si-si-seur. These interpretations of the call were taken from tape recordings made during the establishment of the territories. There may be variations in the length or number of syllables used in the song. Between the songs the male may use the mew or cat call, although the cat call is most often used by the female.

During one of these singing periods I recorded the call exchange between two males for 2½ minutes. The first male sang 22 times or once every 11.6 seconds. The second male sang 18 times or one song every 14.2 seconds. The songs usually alternated from one male to the other. The singing behavior continued from the establishment of territory until mating and nest construction was completed.

Factors Influencing Territory Size and Shape

There were many factors which seemed to determine the size and shape of the territory, such as the amount and kinds of vegetation available to the bird. Where there were thick growths of bitterbrush and sage the territories were smaller and their borders were more sharply defined. Where there were open spaces with small amounts of brush the territories were much larger and the borders less well defined.

Physical characteristics of the area exerted an effect on the shape of the territory. Roads, gullies and tall brush formed borders. The most striking physical characteristic prevailing

throughout all territories was the lack of extremely tall vegetation. Grinnell and Miller (1944) stated that "Forest is avoided and only scattered trees within the brushland are tolerated, but they may be used as song posts. The brush cover is typically low (2 to 4 feet) and spreading, affording runways between plants and underneath foliage."

Description of Each Territory

Virtually all information on the establishment of territories was obtained in 1970, only one nest being found in 1969. During 1970, eight adjacent territories were studied, their size determined and the behavior of each pair closely observed.

Territory number one

The first territory was on the east side of State highway 239. This road constituted the far northwest boundary of the territory. The birds were never seen crossing this road. To the north, east and south, the ground dropped off rather sharply leaving an elevated area where the territory was located. The pair of towhees occupying the territory would go down the slope of this prominence only a few yards, then turn and come back to the flatter part of the territory. The territory had no tall trees and although there were some dwarf elms at the southern border the birds did not use them. The vegetation was of a broken type, consisting of sagebrush and bitterbrush thickets separated by grass and flowering annuals. The ground was almost entirely covered with vegetation, the only bare places being under the bushes (see Figure 4).

The total area of territory number one was 5,431 square feet (see Figure 5).

Territory number two

Territory number two was the first one studied in 1970. It was located by prolonged observation of a singing male. This territory was located on the west side of Utah State highway 239 and below Utah State highway 65. Its borders were less well defined than for territory number one. The only boundary associated with any physical characteristics of the land was to the west where there was the rim of a rather steep gully rimming north and south. The other borders occurred in areas of uniform vegetation and were maintained by territorial calling between males. There was seldom any calling on borders of territory determined by physical features, such as rims of gullies or roads, or open grassy slopes. Territory number two was fairly uniform in ground conformation and was relatively flat with a slight slope to the south. There was a slight depression on the west side near the wash. The area of territory number two was 1,365 square feet and was typical in size, being 147 yards wide and 215 yards long.

Territory number three

The third territory was not studied to any great extent since the nest was deserted early and the pair moved before the borders could be accurately established.

Territory number four

The fourth territory was located directly north of territory

number two (see Figure 5), so that territory two's northern border was the southern border of number four. The males would position themselves on song posts at the junction area about 25 yards apart and exchange calls for hours at a time. Calling by these males would begin at dawn and last until noon or 1:00 p.m. Calling would then slow down until 5 or 6 p.m. when it increased to its former intensity for a short period of one-half hour or so. The gully in area number four was not as steep as in number two and the western border of territory number four extended across this gully to the west side, ending on the top of the west rim. The northern border of this territory was Utah State highway 65, which ran east and west. The east border was in open brush and was maintained by singing. The total area was 7,803 square feet.

Territory number five

Territory number five was located directly east of territory number two. Because of slope of the land it was different from all other territories. This territory was bisected by gully A. and the main portion of the territory was on the east-facing slope of this gully. All borders were in open brush and were shared by other surrounding territories. This territory had a total area of 11,024 square feet.

Territory number six

Territory number six, studied in 1970, was in the same area as territory number one of 1969 and had approximately the same borders. This may have been due to the nature of the terrain. The

vegetation was typical for the general location.

Territory number seven

Territory number seven contained the only extremely tall vegetation in the study area which consisted of a single boxelder tree (Acer negundo L.). This was used as a song post at times by the male. The territory used a common border with territory number five on the south, but was uncontested on the east and west. The border to the east was in poor towhee habitat where brush gave way to grass, the latter not being utilized by towhees. The total area of this territory was 10,591 square feet.

The average size of the territories is 9,700 square feet with the largest being 13,657 square feet and the smallest 5,431 square feet. Figure 5 shows the territories with nest sites indicated.

Female Responses to Territorial Boundaries

The female, after pairing with a male showed a complete disregard or a lack of knowledge for the boundaries of his territory. Some females even strayed from their mate's territories and were pursued by the male into the adjacent territory. An example of territorial interplay was when the female in territory number seven encroached upon the territory of male number five. As she moved into the northern portion of territory number five the male of five came from his song post in the center of the territory. He flew very near female number 7. Male seven flew over and confronted male five. They called at one another, flapped their wings and chased each other about a bit. Male seven seemed to be more

aggressive than male five who soon retreated to his song post. Male seven chased his female back to the central part of his territory. During this activity I never saw any physical contact between two male birds. They flew and screeched at each other but did not engage in sexual fighting. This sort of behavior was only observed at the beginning of the breeding season. Apparently, the female eventually learned the boundaries of the territory of her mate and remained therein.

Courtship

Once the females had arrived and were in proximity to males, a short but intense period of courtship began. The principal features of this was a courtship dance. This dance was performed by the females and, to a lesser extent by the males. The birds would hold their tails erect, their wings extending out from the body in an inverted shape with the tips pointed to the ground. The throat and chest were puffed out and the head and beak were extended upward. The body was moved in a jerking motion in time to the "chit-chit" call. This calling and posturing elicited much excitement from both members of the pair as well as from unpaired males of neighboring territories, so much so, that the adjacent males would leave their territories to investigate. They were then chased off by the participating male.

Mating

These dances and call notes were seen just prior to copulation. The female would assume the dance position and give a few

chits. The male would then fly to her. The female was always low in the brush or on the ground during these activities. The male would mount the female from the side or rear, the female being pushed close to the ground with her tail to one side. The male would lower his tail so that the cloacas of the two birds came in contact. This process would last only a few seconds. At no time during courtship or mating did I see any form of fighting between males and females which involved any actual physical contact.

From the time of first arrival of the female to the time of mating there was a definite change in the calling behavior of the male. When the males first arrived they would call all day long. This behavior continued till the act of mating had been completed. With the commencement of nest building the singing dropped off very sharply. The male then sang only in the morning and evening for short periods of time. Singing during the day was done only when the male was aroused or when other males came close to his territorial border. This passive singing tendency continued through the interval of nest building, incubation, and caring for the young. After the young were fledged, however, the male began to actively sing again.

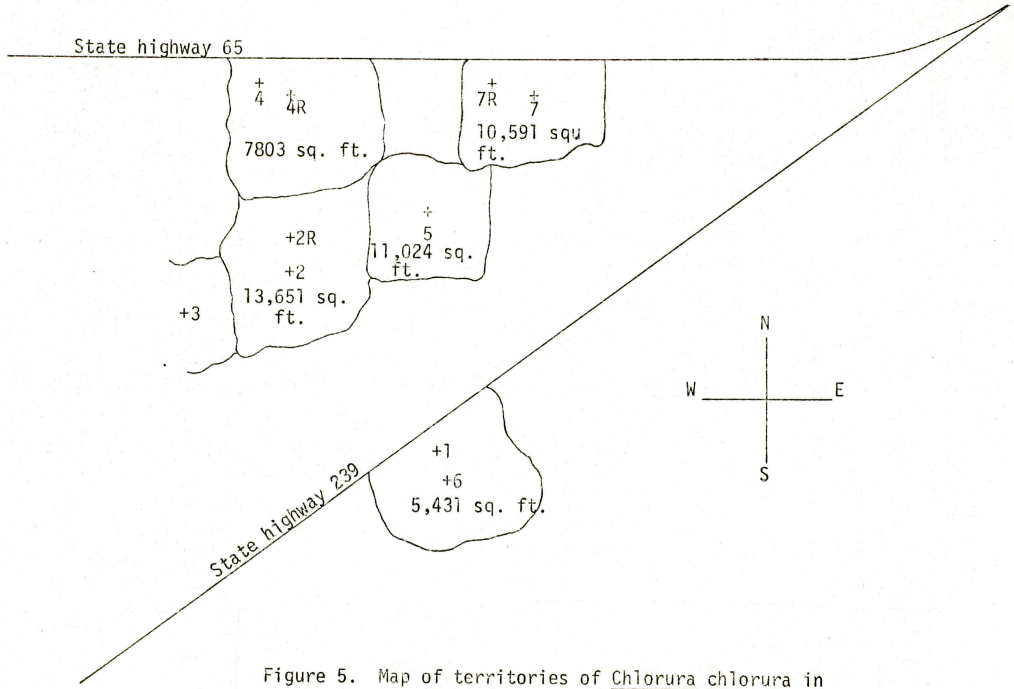


Figure 5. Map of territories of Chlorura chlorura in Mountain Dell Canyon, Salt Lake County, Utah, 1970. + marks location of nest site.

The Nest

The nest consists of a semi cup-shaped platform made of dried, heavy material of stems and twigs. Maximum length was 21 cm, the average length being 12 cm. The radius varied from 1 to 3 cm. Some of the more common and identifiable plants used in the platform are listed in Table 6.

In general, the nest of the Green-tailed Towhee can be described as complex, although not sturdy. Figure 6 shows the nest of a Green-tailed Towhee after the young had fledged. Through the stresses and strains placed upon the nest by the growing young, considerable damage has been done to the structure by the time the young have fledged. A hole occurred in the bottom of the nest shown in Figure 6. This is characteristic of many nests toward the latter part of nestling life. If a nest does not have a hole in the bottom, it is worn so thin that one can see through the nesting material. A possible value of this would be to provide ventilation for the young during the latter part of nesting. This may be correlated with the behavior of the female as she stands over the young shading them from the sun, which penetrates the vegetation.

Figure 6. Nest of Green-tailed Towhee after young have fledged.

Table 6. Plants Used in Nest

Platform			
1.	*Sisymbrium altissimun* L.	Tumblemustard	Cruciferae
2.	*Purshia tridentata* (Pursh)DC.	Bitterbrush	Rosaceae
3.	*Galium aparine* L.	Bedstraw	Rubiaceae
4.	*Solidago sp.* Nutt.	Goldenrod	Compositae
5.	*Artemisia ludoviciana* Nutt.	Louisiana sagebrush	Compositae
6.	*Aster chilensis* Nees.	Aster	Compositae
7.	*Epilobium paniculatum* Nutt.	Autumn willoweed	Onagraceae
8.	*Lupinus sp.* L.	Lupine	Leguminosae
Outer Cup			
1.	*Poa pratensis* L.	Bluegrass	Gramineae
2.	*Agropyron cristata* (L.) Gaertn	Wheatgrass	Gramineae
3.	Other grasses not identified		
Inner Cup			
1.	Rootlets		
2.	*Polygonum sp.* L.	Knotweed	Polygonaceae

Sitting on this semicup platform was the first true cup. This was made of coarse, dry grass material, notably the straw or stock that supports the grains. There were a few other dry plant stems mixed with the grass but none could be identified as to species. This course cup was lined by a thin layer of knotweed (*Polygonum*

sp.). This thin layer completely lined the coarse grass cup and served as a foundation for the fine rootlets which formed the lining. These rootlets have the appearance of hair. They are smooth in texture and are wavy like deer or elk hair. Hair and other material have been reported as a lining for towhee nests. Linsdale (1936:113) stated, "Five nests were found in sagebrushes and the nest lining, where recorded, was partly of black horsehair." Also, Gabrielson and Jewett (1940:551) stated that porcupine hair may be used. Tanner and Hayward (1934:232) described the nest as rather a frail structure, made of dried grass and small twigs and lined with a little sage bark and horsehair. Of the nests I studied only one had hair in the cup lining consisting of one strand of elk hair.

The nest varies in shape from round to oval depending on its location. Nests built in cramped spots tend to be oval whereas those built in more spacious areas tend to be round. The width or diameter of the nest from outside rim to outside rim ranges from 14 cm to 10 cm with an average of 12 cm. The inner cup of the nest ranges from 8 cm to 5.5 cm with an average of 6.8 cm. The depth of the cup ranges from 6 cm to 3 cm with the average depth being 4 cm.

Duration of Building and Role of the Sexes

During the course of this study I observed several nests being constructed. In each case the activity began shortly after dawn and continued into the afternoon, with work stopping about

2 p.m. each day. The female built the nest. She worked fast and took little notice of activity around her. In the study area there was ample building material within a short distance from the nest site. A visit was made to the nest site by the female with material every few minutes. There was almost frantic activity. After about two and one-half days the nest was completed.

During this time the male was quiet. There was little singing. This was noticeable, because until mating and nest building commenced the male sang almost all day. The male was never seen to approach the nest during construction nor to help in any way.

The Eggs

In California nests ready for eggs have been reported as early as May 22 (Rowley 1939:253), but in the area I studied the first egg was not discovered until May 29. From subsequent nest finds and hatching dates it is apparent that most birds in the area began to lay about the same time, namely from May 29 to June 1. Harkin (1961:181-82) analyzed the data for the nesting birds of Utah and found that "the peak of the Green-tailed Towhee's clutch completion occurs in the last ten days in May." There are many factors operating in determining the exact time at which the Green-tailed Towhee lays its eggs. Inclement weather during and prior to arrival probably results in late nesting.

Of the 10 nests studied only 9 were used in the calculation of clutch size. Nest number three was abandoned before clutch was complete. These data together with 28 clutches recorded by Norris (1968) shows that of these 37 nests, three had two eggs, twelve had three, nineteen had four, three had five with an average 3.32. Harkin (1961) also reported a clutch size of 3 to 4 eggs for the Green-tailed Towhee in Utah. The coloring and size of the eggs collected was typical for this species and is described adequately by Norris (1968:553).

The interval between completion of the nest and the laying of the first egg was two days. The first egg was laid on the fourth or fifth day after construction of the nest began. One egg was laid each day thereafter till the clutch was complete with the clutch size normally being 3 or 4 eggs. Upon laying of

the last egg the female commenced incubation. Some differences were observed between the first laying period which started on May 29 and lasted till June 5 and the later nesting period which had no precise limits. Later nestings simply commenced with the destruction or abandonment of the first nest. During the second nestings the female remained on the nest during the laying period. (This, however, did not affect the hatching of the eggs.) The temperature was higher during this later period and the female may have been protecting the eggs from the direct sun. This was observed to be the case with the young during this same time. Norris (1968:552), in reporting on the Green-tailed Towhee found that on May 27, 1936 the first egg appeared before 10:45 a.m., a second egg on the 28th before 8:35 a.m., a third egg on the 29th before 8:45 a.m., and by 9:20 a.m. on May 30 incubation had commenced. This sequence corresponds to my experience with times of laying. Of the ten nests studied three were found before egg laying had commenced. All eggs were laid before 10 a.m. and mostly during the early hours from 6 a.m. to 9 a.m. A summary of the egg data for the present study appears in Table 6.

History of Each Nest Observed

The Nesting Site

Shortly before or during mating the nest site was chosen by the female. This site showed little correlation with the size or shape of the territory or the song posts of the male. Some nest sites were at or near the border. Others were in the center or to one side of the territory (see Figure 5). There was no preference as to the direction or exposure of the nest to the sun. The only unifying factors that were evident were that all nests were located in sagebrush (Artemisia tridentata) which were 45 cm to 119 cm in size and all were close to the ground. The sagebrush was, in general, always associated with bitterbrush (Purshia tridentata). In the study area there was exclusive selection of sagebrush as a nesting site, but in areas where sage is not present or at least not abundant other low bushy shrubs are used. Ridgway (1877:496) observed this fact. "In the position of its (Green-tailed Towhee) nest there was a rather unusual uniformity of habit manifested, especially by the birds of one locality; thus, those found at Austin (Nevada) were all placed in the thickest part of low bushes . . . at a height of eighteen inches to two feet above the ground; the same was usually the case in Parley's Park (Utah)." The uniformity in plant selection is not for plant species but rather for plant physiognomy or general habitat aspect.

Norris (1968:551) in describing the nest, reports that eleven nests were in sagebrush, seven in waxberry, and four in snowbush. He also reported two nests being associated with scrub oaks

Quercus gambelli Nutt.), and one nest each in chokecherry (Prunus virginianus L.), juniper (Juniperus L.), and gooseberry (Ribes L.). Bailey (1928:709) found them nesting on or near the ground in wild currant bushes, mountain snowberry, sagebrush, chaparral and cactus.

Figure 7. Nest of Green-tailed Towhee.

Figure 7 shows a typical nest of the Green-tailed Towhee in the study area hidden deep within the center of the sagebrush. Note the dense foliage to the rear and sides.

Behavior of females is so furtive that locating nests is a very difficult process. Nevertheless, a fair sample of nests was obtained. Whereas the first season only one was located, with experience during the second season, nine nests were found.

Nest number one

Nest number one was found on July 18, 1969. It contained three eggs at the time and was located in a small sagebrush 35.5 cm from the ground. The nest was well concealed from the top by the vegetative overhang and was situated near the periphery of the bush. It was 16 cm from the center of the nest cup to the edge of the bush on the north side. The nest was located 25 meters from the road in typical towhee habitat. I was able to make many observations at this nest, recording daily weights and noting the behavior of the young. The female became accustomed to my presence and would only leave the nest when I approached to within a few inches. During this time the male was seldom seen or heard. The three eggs hatched on July 20. I was not present at the time of hatching. When the young were discovered at 12:00 noon they were dry and all egg shell particles had been removed from the nest. The female brooded the young continuously for the first five days of nest life. During this interval, when I approached the nest she would leave in the same manner as she did when incubating eggs earlier, namely sliding off the nest and running down the plant stock to the ground. She was never far away but remained silent until I began to weigh the young. Then she would mew but would not attack.

Nest number two

This nest was found in 1970 on May 25. The nest was in the process of being built at the time and only the heavy sticks of

the platform were in place. The nest was in a sagebrush which was situated in a very shallow basin at the beginning of a wash. I was able to observe the construction of the nest as the female worked almost frantically to complete the task. Construction began at the first light of dawn and stopped around 1:00 p.m. Two to two and one-half days were required to complete the nest. The nest was placed on the east side of the bush, 42 cm above the ground and well into the center of the bush. It was 45 cm from the center of the cup to the periphery of the bush. The nest was well concealed from all sides and from the top.

After the nest was completed, the female was inactive for the next two days. She remained in the thick brush feeding and resting. The male sang for short periods in the morning and evening. On the third day after nest completion, the female began laying. All eggs were laid in the early morning hours starting on May 29. With the laying of the fourth and last egg on June 1, the remale remained almost continuously on the nest. I was able to make detailed observation of the incubating behavior of the birds from a blind. Figure 8 shows the time that the female was on and off the nest during the incubation period. On June 14 the eggs hatched and the female commenced brooding the young. Figure 11 shows the time off and on the nest during the brooding period and the times food was delivered to the young. Brooding of the young continued for four days after which the female would stand over the young during the day as if to shade them. By June 21 the

young birds were no longer in the nest. The nest had been disturbed; the rootlets of the interior cup were pulled out of place and the pair was nowhere in sight. I believe the young were taken by some predator because on the next day the male of the pair was singing territorially with much more vigor and for longer periods than during the nesting period. Also, the female had begun to build a new nest.

Nest number three

This was found on the same day as nest number two and was similarly situated at the head of a wash in a shallow but wide basin about 75 to 100 meters across. The nest was in the upper two-thirds of a sagebrush, facing south, 16 cm from the outer edge of the bush. The nest contained one egg. At the time of discovery the pair nearby showed great concern and called repeatedly with mews and chits. On consecutive daily visits the nest was found to be unattended but the egg remained in the nest. On June 1 when I visited the nest, it was empty. There was no clue as to how the abandoned egg was removed. The pair remained in the area but I could not locate a new nest. A similar situation was reported by Grinnell, Dixon and Linsdale (1930:407) where they found a nest containing three fresh eggs with the adults close by. But shortly after the discovery was made, the birds deserted the nest, so the eggs were collected. These experiences indicate that nests are subject to desertion. This, along with the difficulty in finding nests, led me to be extremely careful in my

observation of future nest sites so as to prevent desertion by the adults.

Nest number four

On June 2, 1970 as I watched a male sing his morning territorial song, a female flew toward the male from a clump of sagebrush. The two mewed at each other and fed in the bushes at the top of gully 2 on the embankment of highway 65. After feeding for a short period the female returned to the same clump of bushes from which she had first flown. Upon examination, this clump of bushes proved to be the location of nest number four. It was on the west-facing side of the gully near the top, and only 10 meters from the road. However, the road was raised 4 meters above this spot. The nest was in a sagebrush and was 63 cm from the rim of the cup to the ground. The nest was well concealed, being situated near the center of the bush but slightly closer to the southeast side. The nest contained 4 eggs which had been incubated for a few days. Incubation proved normal until the nest was abandoned on June 9. On this date I was studying nests 2, 4, and 5 when at 9:55 a.m. rain started to fall. It was light at first but by 12:40 p.m. was so heavy that I was forced to leave the blind because of water collecting on the top and running in on me. I checked the nests and found that in number two the female was sitting on the eggs. Her posture was very low and her body was extremely wet. Nests four and five showed a similar condition but nest number four was unattended. The whole nest was soaked

and the eggs were cold and wet. The rain increased in intensity, turning to hail at 2:30 p.m. which continued until 3:15 p.m. One-fourth to one-half inch of hail covered the ground. I checked the nests again at 4:30 p.m. and this time found all unattended, wet and with the eggs cold to the touch. The inference was that the hail had been so severe that it had driven the females off the nests, leaving the eggs exposed to the elements. My first thought was that all the nests had been abandoned, and that the cold would have destroyed the developing embryo. However, I checked the nests on June 11 following the storm and found parents incubating the eggs in nests number two and five. Nest number four, however, was permanently abandoned. I collected the eggs and examined the embryos which showed no signs of life. The male of this pair began to sing again with great vigor and patrolled his territorial borders constantly, but no female was seen or heard near this male from the time of nest abandonment on June 10 until June 18. On this date a female was seen engaged in a mating chase with the male. In other instances of renesting, nest construction was started by the females within two days after nest destruction. However, I feel that the female in area four had not only abandoned the nest but also the male and territory. Another alternative is that she was killed. In any event, the male sang territorially for 8 days before a female was again seen or heard in his territory. The inference is that this was a new female.

Nest number five

On June 9, 1970 as previously noted, rain had been falling all morning and all nests under observation and eggs were being attended by one of the parents. At 9:00 a.m. I observed a towhee feeding on the east-facing slope of gully number one. It behaved like a female, staying low, close to the ground and never ascending to the tops of bushes to sing. It called only with a mewing sound. As I watched, this bird flew to a sagebrush in the center of a small clear area. She remained in the bush, which upon examination was found to contain nest number five. This was deep in the sagebrush near the center but slightly to the east side. There was a distance of 45 cm from the rim of the cup to the ground. The somewhat isolated sage bush in which the nest was located was surrounded by a growth of dense sage and bitterbrush thicket. The ground between the nest and the surrounding thickets was covered with various tall grasses, the predominant ones being Poa pratensis L. and Agropyron cristatum (L.) Gaertn. Many forbs occupied this area, the predominant one being Balsamorhiza sagittata. The sagebrush with the nest was located on the east-facing slope of the gully number three approaching midway to the gully bottom. The nest contained three eggs.

On June 15 at 7:30 a.m. two of the three eggs had hatched. The third remained unhatched but was brooded all day. I checked the nest at 8:50 a.m. and again on the 16th. All three eggs were now hatched. I weighed the young and found a definite weight

difference between the two that hatched first and the third. The first two weighed 8.9 gm and 8.8 gm. The third weighed 6.4 gm. This weight differential continued until the end of the nestling period when the smaller bird began to catch up to its nest mates. Weight and growth data are shown in Figures 12 and 13. The parents were more solicitous and protective of this nest than at any of the others. The female feigned injury more often and both parents were never far from the nests during my visits to weigh the young. If one of the young made a protest or called, the parents would fly frantically close to me, diving and screeching or uttering loud peeps. The young birds grew very rapidly while in the nest. Increase in size became a problem and created strain on the nests. After 6 to 7 days the floor of the nest became weak. Looking directly into the nest from above one could see through the bottom. By June 23 the young were standing in the nest and on the 24th they left the nest. During the weeks that followed I would stand in the thickets and listen to the young and the parents chirp at each other. The parents were actively feeding and caring for the young. There was no evidence of a renesting by the pair in this territory. Once the young were old enough to fend for themselves the territory was deserted.

Nest number six

The sixth nest was found on June 9, 1970 at 6:15 a.m. in the same area occupied by nest number one in 1969. Nest number six was only 16 meters away from the nest site of number one. I have

no evidence that birds return to the same area each year, but the use of this area for two years indicates that it had some attraction as towhee habitat. Nest number six was in a very low sagebrush that was almost level with the surrounding grasses and flowering plants. The nest was situated in the top of the bush 23 cm from the ground and contained 3 eggs. It was concealed from all sides and the top by vegetation. I was able to find this nest because of the behavior of the pair. The male was singing as I approached his territory. At the same time I heard the mewing of the female who was low to the ground moving from bush to bush feeding. As I watched, she flew to a low bush in which she remained. Upon approaching, the female sneaked from the bush in the typical female "flushing" pattern which gave away the nest's hiding place. I used this behavior to locate nests in other potential nesting areas.

The eggs in nest number six hatched in the same sequence as in nest number five with two eggs doing so on the 15th and the third on the 16th. On June 17 the nest was empty but the parents were close by, being very excited and flying at me. This nest was close to the stream where I had seen magpies flying from bush to bush many times. Other predators had been seen and trapped in these areas such as the long-tailed weasel, the spotted and striped skunks. One of these predators probably got the young.

Nest number 7

Northeast of nest number six near highway 65 stands the only tree in the study area. As previously noted, this tree served as a song post for a male. For several days I had tried to locate the nest in this male's territory and tried all the techniques learned in finding other nests. I went there repeatedly early in the morning trying to find the female while feeding and then follow her to the nest. This was to no avail until June 16 when at 6 a.m. I observed both the male and female at the same time and was able to follow the female to her nest. It was located 66 cm from the ground, which was one of the highest I had observed. This nest was not oval as all others had been. Rather it was built between two upright branches which made the shape of the nest oblong. It contained four young birds about two days old. The nest was, as usual, well concealed and was situated on the southern side of the bush 21 cm from its edge. The bush containing the egg was in a stand of uniform-sized sage on a south-facing slope. The female was exceptionally good at injury-feigning. She would drag one wing on the ground while flattening the other as she ran from thicket to thicket. On June 21 the nest was empty. As I approached I noticed a magpie on a fence post 23 meters from the nest. The parent towhees were very excited, flying and calling. In the days that followed, the male returned to the calling behavior used in first establishing territories. The female remained in the territory and the pair renested.

Second Nesting

If, during the sequence of the summer activities, courtship, mating, or nesting was interrupted by the loss of mate, nest or destruction of young, the male of the disrupted pair began to sing again and, if successful in maintaining the pair bond or acquiring a new mate, the nesting sequence started over again.

Nestlings in nest 2, 3, 4, and 6 were destroyed as noted. Of these four territories, in three there were renestings. Number 2 nest was destroyed on June 21 and by June 24 the female was observed constructing a new nest. This nest (2R) was located 157 feet directly north of the original nest. The nest was in a low sage 35 cm from the rim of the cup to the ground. Construction of this nest proceeded in the same manner as all other nests. Two days were required to build it with the nest being finished on the 25th. On the 25th the pair was seen in a mating chase with the female calling to the male with her mating call. The first egg was laid on the 27th with one egg being depostited each day for the next two days. With the laying of the third egg, incubation commenced and proceeded normally. Hatching also proceeded normally for a nest with three eggs. Two eggs hatched on the 11th of July and the third on the 12th. The young of this second nest were short-lived, for on July 16th the nest was empty. Neither parent was present, nor did I see any towhees in the territory for the remainder of the summer. I have no clue as to the cause of this disturbance.

Nest number four was destroyed by inclement weather on June 10. On June 18 I saw the pair of parent towhees in a mating chase and copulation occurred in the low brush. On June 19 the female was observed making frequent trips to a single sage bush in the middle of a small clearing. Closer examination revealed a partially built nest (4R). It was near the center of the bush 30 cm from its rim to the ground and 124 feet to the southeast of nest number four. The nest was not concealed as well as all other nests had been. This was due to the circumstances that the sage was not as thick as most, and the nest was situated toward the bottom of the bush in the more exposed, branchy part. While there was ample protection from above, the sides were rather open and left the nest unprotected. Construction of nest 4R was completed on the 20th day of June and the first egg was laid on the 22nd. The egg was laid before 9 a.m. When I checked the nest at 1 p.m. I found the female incubating it. The second and third eggs were laid on the two following days, one each day. On each of these days the female was sitting on the eggs. This constant attendance was unlike the other bird's nesting behavior. In all others, the female remained on the nest only after the laying of the last egg. This behavior seemingly affected the rate of the development and hatching of the young, for they hatched on the 5th day of July, only 11 days after the last egg was laid. This compared with 13 and 12 days for the two other recorded incubation times. This shorter time of development was presumably correlated with temperature increase from the longer and more continuous incubation.

Development of the young progressed normally with the fledglings of this nest. They were fed and cared for by both parents. The female was last seen with her full-grown young on July 28, after which their whereabouts was undetermined. They had moved away from this territory. No towhees were seen there the remainder of the summer

The male's behavior during the incubation and nestling life was similar to others studied. After copulation and during nest construction his territorial singing decreased markedly. He sang only in the mornings for short periods and the duration of the singing interval was short, from 6:00 a.m. to 7:15 a.m. This reduction in singing remained in effect until the latter part of nestling life where there was a noted increase.

On June 21 the young in nest number 7 were destroyed. For the next two days the pair of adults were active in the area. The female was feeding and resting in the low brush and the male sang territorially most of the day. On the 23rd the male was seen chasing the female. He was never far from her during the morning hours. After the 23rd the female was not seen, but the male behaved as though copulation had not occurred until the 28th when there was a decided drop in his singing. During the interval between the 23rd and the 28th the female may have left the area or a new mate could have come into the territory. In any event, there was a definite time lapse of 5 to 6 days between nest destruction and the building of the new nest and the laying of the next clutch of eggs.

I made a special attempt to locate a new nest because all behavioral characteristics led me to believe there was one. I watched the territory at early hours and late in the evenings, trying to see a female or catch a female off the nest. I walked through all the thickets trying to flush a female, but not until July 14 did I find the nest. The nest was only 20 feet from where I had been sitting and watching for the past two weeks. I had walked past it daily without the female being disturbed. This may have been due to the circumstance that the female had become accustomed to me at the first nest and so did not flush when I walked by the new one. If it was a new female she was, from the start, not frightened by my presence. In the chance finding of the new nest (7R) I walked directly toward the bush and was changing my direction when the female flushed. I only caught a glimpse of her movement, but her fleeing action gave away the nesting site.

The nest was high in the sage 66 cm from rim to ground. It was exceedingly well concealed from all sides and the top. The nest contained 4 eggs. This was the only one of the renests to have this number. The first nest of this pair had had 4 eggs also. Furthermore, the eggs hatched in an unusual sequence, namely, two on July 16 and two on July 17. Since the laying and incubation of these eggs had not been observed I can offer no explanation for this unusual hatching. The young were progressing normally in their development until July 20 when the nest was robbed. No signs of a struggle were apparent, but the young had disappeared. The

female was note seen in the territory again, although the male remained and sang territorially as if he was trying to start anew for the third time. No other female was seen nor was another nest found.

Incubation

Role of the Sexes

As previously noted, by the time of egg-laying, the male of the pair has, for the most part, stopped his singing. During nest construction and laying of the eggs his activities were limited to feeding himself. He made no attempt to help the female or to feed her. This pattern of activity apparently continued through the incubation period. Males were never observed at the nest or sitting on eggs. Three males were collected from areas adjacent to but not in the study area. Brood patches were lacking in all three. This corroborates the observation of Bailey (1952:128) who examined breeding male Green-tailed Towhees and found no brood patch. He concluded: "Incubation patches are found in both males and females according to their participating in incubating the eggs. Only females incubate and have patches in the Strigiformes, Falconiformes, Trochilidae, and most, if not all Passeriformes." The Green-tailed Towhee is a member of Passeriformes and the males do not have incubation patches. This, coupled with my negative observations as to incubating behavior, indicate that the males do not participate in incubation. Thus, incubation is solely a function of the female.

Incubation begins with the laying of the last egg. Of the nests studied, only three were under continual observation from the time of laying until hatching. For these the incubation period was 11 days, 12 days and 13 days. The 13-day period was for an initial nesting, whereas the 11 and 12 day periods were for renestings.

Incubation for the other sets of eggs must have taken about the same time, for two other nests hatched on or near the same day (see Table 7).

Figure 8 shows the times of a female off and on her nest during a four-day interval during incubation. On June 2 the female was off the nest during the time observed for an average of 17 minutes and on the nest for an average of 27.7 minutes. The eggs were covered for 74% of the time observed. On June 3 the female left the nest for an average of only 7.8 minutes and remained on the nest for 51 minutes for a percentage of egg coverage of 83%. On June 5 the female was off the nest for an average of 5.3 minutes and on the nest for an average of 20.5 minutes or 86.8% of the time observed. On June 10 the female remained off the nest for an average of 12.5 minutes and on for 46.7 minutes or 85% of the time observed. The initial observations made on June 2 may be misleading because the birds seemed to be disturbed by the closeness of my blind. Nevertheless, the percentages of time on the nest indicate a tendency for the female to remain on the nest for longer periods of time and a greater percentage of the time as the incubation progresses. There was no regularity or basic rhythm to the on and off periods. Long or short periods occurred at any time of the day. The incubation instinct causing females to remain on the nest seemingly constitutes a stronger stimulus than hunger or other factors that would cause the female to leave the nest.

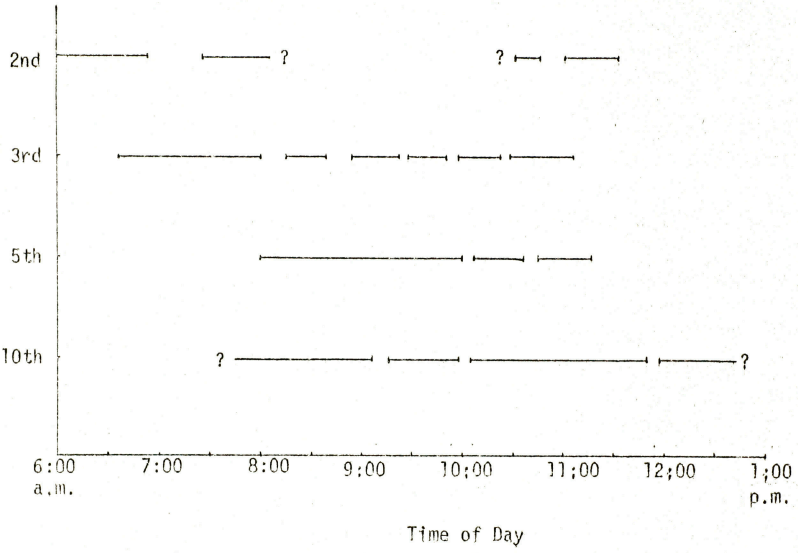


Figure 8. Brooding periods from 6:00 a.m. to the end of observation period. Question mark (?) indicates that the exact beginning or end of a brooding period was not known. Solid line indicates time of female on the nest, whereas spaces indicate intervals off the nest.

Behavior During Incubation

Note has been made of changing behavior patterns whereby during early days of incubation the female leaves the nest with the slightest disturbance, whereas as incubation proceeds there is a reluctance to leave the nest. Another item pertains to a female's reaction to a blind. At 6:55 a.m. while watching nest number 1 from a blind 25 feet away, the male called to the female. She left the nest and flew to him. They were very close to the blind and called with a mewing sound. At 8 a.m. the female again left the nest but this time flew straight at the blind as if to protest its presence. Because of this reaction I moved the blind to a distance of 75 feet from the nest and concealed it in heavy brush. No further protests were made.

During the time of incubation a very interesting general behavioral pattern was observed. This pattern was noted by Miller (1951:307) and termed the "Rodent-Run" of the Green-tailed Towhee. He describes the run as follows:

> "For some years I have been of the opinion that the nest-flushing run of the Green-tailed Towhee (Chlorura chlorura) has a significant resemblance to a running chipmunk (rodent genus Entamias) (sic). In 1934 (Wilson Bull. '46:166) it was noted that a nest of this towhee was found "as a bird flushed from it in the characteristic "greentail" manner, that is, by dropping to the ground and running with tail elevated, thus resembling a chipmunk running through the brush."

My observation of this flushing pattern revealed that the towhee not only resembled a chipmunk but at times indulged in

injury feigning, specifically simulating a broken wing. She would drop one wing to her side and flap the other in a very conspicuous motion. This latter feigning was only performed when I was very close to the nest. In contrast, the "Rodent-Run" behavior was used when I was approaching the nest from a distance of about 15 to 20 feet.

I also noted a difference in the way the female left the nest. When I was close to the nest the female would come off the nest in the lowest possible position, almost in a sliding motion, and she would run down the inner stock of the sagebrush, drop to the ground and either run away like a chipmunk or feign injury. But when I was concealed in a blind and my presence was undetected the female would fly directly from or to the nest or to the brush only a few inches away from the nest. "Rodent-Run" behavior then would seem to demonstrate the towhee's keen awareness of approaching danger.

The best observations pertaining to the actions of a female on or near the nest pertained to female number 2. When returning to the nest she always approached from the south or rarely from the west. She flew directly to the bush and landed 15 to 20 cm from the nest. During incubation she was entirely silent, and only moved to peer at movements in the surrounding brush. At times she would stand and stretch her wings or fluff her feather, push out her chest and then settle down on the eggs or drop her head as if she were moving the eggs. Once she stood and turned around 180 degrees, fluffed out her feathers and then settled down again. Observations were made with a 20 power spotting scope, which

enabled me to see great detail. At times the female seemed to doze off for short periods of time. Her eyes would slowly close, then pop open as if to keep from going to sleep. For most nests the females posted themselves in the nest in the same manner at all times; that is, they faced the same direction while sitting on the nest. Most of the time this was toward the side with the greatest exposure or the side that provided the largest expanse of view.

Hatching

Time of hatching of the eggs seems to be dependent on the number of eggs in the nest. Nests number five and six had three eggs each, and both began hatching on the same date, June 15. In each case two eggs hatched on the 15th, with the third egg being hatched on the 16th. The only other nest to be observed during the hatching interval was nest number 7R. It had four eggs, of which two hatched on the 16th of July, with the other two on the 17th. Subsequent to hatching the shells of the eggs were removed from the nest. Usually the parent discards them some distance from the nest but the female may eat them as do some other Passerines. No fragments of eggs were found at the base of bushes or near the bushes utilized for nests.

Newly hatched young are helpless and weak but they respond to slight movements of the nest. They raise the head and neck weakly weaving them at the time.

Figure 9. Two newly hatched young in the nest with unhatched egg. The third egg hatched on the next day.

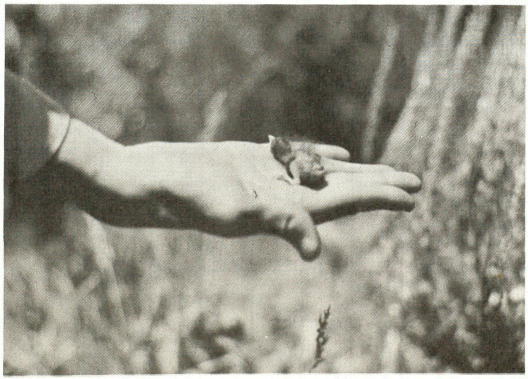


Figure 10. Newly hatched Green-tailed Towhee. Note the dark but sparse down.

Table 7. Summary of Nesting Data

Nests	Date	Dates of Laying	No. Eggs	Date Hatched	Incubation Period	Date Fledged	Date Destroyed
1	7-8-69		3			7-29-69	
2	5-25-70	5-29, 30, 31 6-01-70	4	6-14-70	13 days		6-21-70
3	5-25-70		1	Did not hatch			6-01-70
4	6-02-70		4	Did not hatch			6-10-70
5	6-09-70		3	2 6-15-70 1 6-16-70		6-24-70	
6	6-13-70		3	2 6-15-70 1 6-16-70			6-17-70
7	6-16-70		4	6-14-70 *			6-21-70
2R	6-22-70	6-27, 28, 29	3	7-11-70	12 days		6-16-70
4R	6-18-70	6-22, 24, 27	3	7-05-70	11 days	7-16-70	
7R	7-14-70		4	7-16-70			6-20-70

* Calculated from weight of other young nestlings.

Care of Young

Brooding Period

Brooding of the young by the female during the first few days after hatching was almost as continuous as was incubation. The female left the nest very seldom. Figure 11 shows the times on and off the nest as well as the times the female or male returned to the nest with food, (the latter times being indicated by a line followed by an "F" for female or "M" for male).

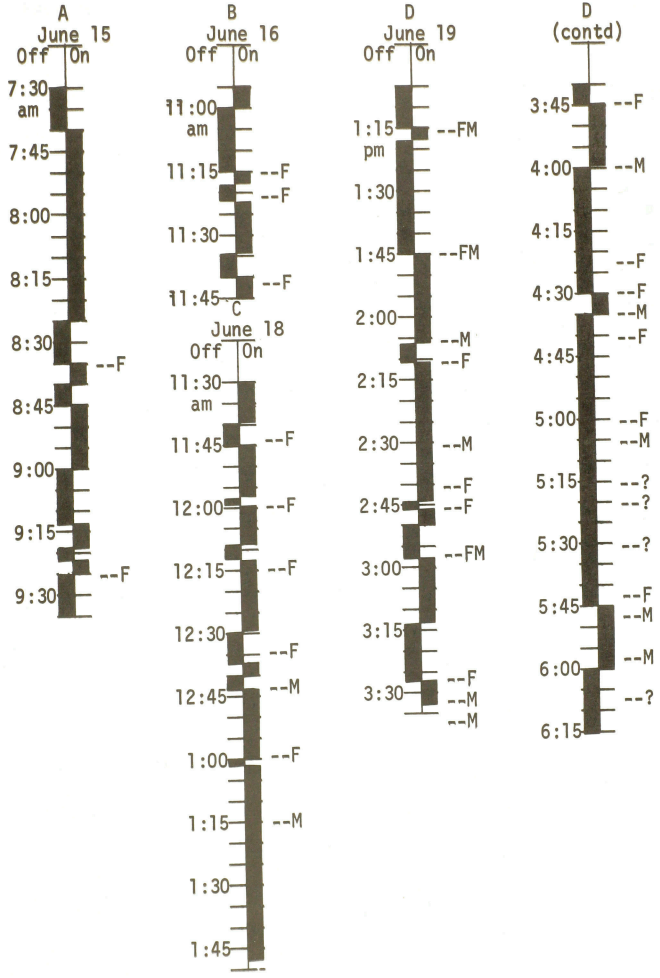
The information in Figure 11 was obtained from nest number 2 which was observed from a blind using a 20 power spotting scope. The eggs in this nest hatched on the 14th of June. When I arrived the female was off the nest. The young did not open their mouths when I moved the nest, from which I infer that the female probably had been feeding them just prior to this time and so they were not hungry. She returned at 7:40 a.m. without food and began to brood; this session lasted 50 minutes. She then left the nest for 10 minutes, returning this time with food which she fed to the gaping young. Because of the distance and the angle of view I could not see the activity of the nestlings during these early stages. I could only see the tips of their beaks slightly above the rim of the nest. Their behavior, as compared to the forceful, active gaping toward the latter part of the nestling life seemed passive.

On June 16th the nest was observed for 1 hour and 5 minutes, between 10:55 a.m. and 12:00 noon. During this time the female fed the young 3 times and brooded them for a total of 26 minutes. On June 18th this same nest was observed between 11:30 a.m. and 1:40 p.m. for 2 hours, 10 minutes (see Figure 11C). During this time the female fed the young six times and the male fed them twice. The male may have fed the young on the 15th or 16th but this is very difficult to determined. Both male and female look identical and only when they were both at the nest could I positively say that the male was feeding. I was able to determine on the 19th from the behavior of the two birds which one was the male. As stated before, the male never brooded the eggs. This behavior was carried into the nesting period also. When the male came to the nest to feed the young he never sat on the nest or made any attempt to brood the young, neither did he try to shade them as did the female. On the 18th and 19th, during the time the nest was observed, the female did not brood the young, although she did remain at the nest for as long as 21 minutes shading the young. She would stand over the young, slightly pressing her body toward them, shading them from any light which would come through the bush.

Feeding

Because of the speed with which the female fed the young it was difficult to determine the exact kinds of food the young were fed. General observation, however, led me to believe that their

Figure 11. Brooding behavior of female after hatching. Food brought to nest by female indicated by --F; Male delivery indicated by --M.



diet consisted mainly of insect larvae. The Brown Towhee has been reported to have fed its young on insect larvae entirely (Davis, 1960). On July 3rd as I sat under the elm tree at the north end of territory 7, an adult flew to within a few yards of my position. It did not see me as I sat very still. It scratched in the soil around the roots of the tree and found a greenish grub which it held in its beak and flew off in the direction of its nest. This supports my observation at nest number 1. The parents, when feeding, held the food in the beak. There is no evidence to support feeding from the crop. When arriving at the nest the female always approached from the southeast side of the nest, entering the bush in the same direction. The male always came from the west and entered from that direction. The parents were seen crushing or softening and cutting the larvae while the young waited, gaping. This crushing and cutting was done with the beak, similar to that done by robins to earthworms. The parents feed small pieces to the young. At times, too large a piece was fed and the adult would retrieve this from the nestling's mouth and cut it into a still smaller piece or pieces. Also, the parents would bring food to the nestling and feed only part to them, eating the rest themselves.

Water balance would seem to be an important factor in determining the diets of both parents and young. There was no free water in the area studied. If the young or adults were fed seed exclusively they would perish, because Green-tailed Towhees

cannot live on metabolic water alone. Smith and Ohmart (1969) fed Green-tailed Towhees on commercial finch seed mix, mixed with chick starter mash, the mixture having a moisture content of 7.0% and found that they need 3 ml of distilled water to maintain body weight. The inference is that succulent insect larvae must supply an adequate amount of water for both adults and young in the wild.

Coprophagy

All nests were remarkably clean and showed no visible signs of fouling. The sanitation of the nest was maintained by the parents in the following manner: The fecal material passed by the young is surrounded by a gelatinous substance commonly called a fecal sac. The newly hatched nestling simply defecates while sitting, but as he gets older the nestling elevates his anus to eliminate the fecal sacs. This usually takes place shortly after feeding. After feeding, the parents stand on the rim of the nest and watch for the appearance of this whitish substance of waste material from the young. When one appears the adult immediately picks it up with its beak and eats it. This behavior has been observed in many Passerines, including the Rufous-sided Towhee (Pipilo erythrophthalmus) (Davis, 1960:453) and is termed coprophagy. In most Passerines the adults only eat the feces when the nestlings are very young. However, the Green-tailed Towhee eats feces at virtually all times. Only once did I see a parent fly away from the nest with fecal material in its mouth.

The fecal contents of the young are heavy in salts, being mixed with excretory wastes, thus the eating the waste of the young would seem to place a strain on the water balance of the adult. A study of the physiology of this behavior is certainly called for.

Development of Young

During the nestling period I took weights of the developing young. Weights were collected for nests 1, 2, 3, 4, and 5 only. Renests and nests found after June 21, 1970 were not weighed. This was because of the high mortality of the young in the nestling stage. I did not want my daily disturbance of the nest and nest site to attract predators. Figure 12 shows the development of all young which were observed over a seven-day period with regression line plotted. From Figure 12 it is apparent that toward the latter part of the nestling life the weight of the young tapers off to a point at or near 20 grams. Figure 13 shows this nicely. It pertains to the development of the young in nest number 1. As in the other nests studied there seems to be great differences in the weights of the young when they are first hatched. This may be due to the difference in hatching or laying time. Although incubation generally began at the laying of the last egg, the young from the first egg and the second have an advantage over the last to be laid. This is pointed out in Figure 13. The first and second young are closer together in weight and weigh more than does the third. This dicrepancy persists until the latter two or three days in nestling life. Then the first and

second young taper off in weight gain while the third young maintains its rapid growth (Figure 13) and thus catches up. Figure 13 shows that during the last day of nestling life bird number 1 gained only 0.3 grams, bird number 2 gained 1.4 grams, whereas bird number 3 gained 2.2 grams. Nestlings of other nests showed similar trends, especially where the eggs hatched at different times.

Defense of Nest and Young

As has been discussed previously, the "Rodent-Run" and injury feigning of the adult Green-tailed Towhee may insure some protection or distraction from the nest and young. The location of most nests also tends to give protection and concealment, since all nests studied were placed near the center of the bush resulting in vegetative (sagebrush) cover on all sides. This not only protected the young from the view of potential predators but also afforded protection from direct exposure to the sun. Vocalization by both male and female may serve as a deterrent to predators by calling at the intended predator, often accompanied by actual chasing the prey species. This action was shown when I was weighing the older nestlings. They would sometimes give a weak squawk. This brought both parents to the nest site screeching and flying very close to my face. They continued to do so until it was apparent they could not drive me away, whereupon they returned to the surrounding bushes and called intensely. This behavior demonstrated the inability of the adults to protect

their young against large predators such as bobcats and coyotes and their dependence on concealment and deception.

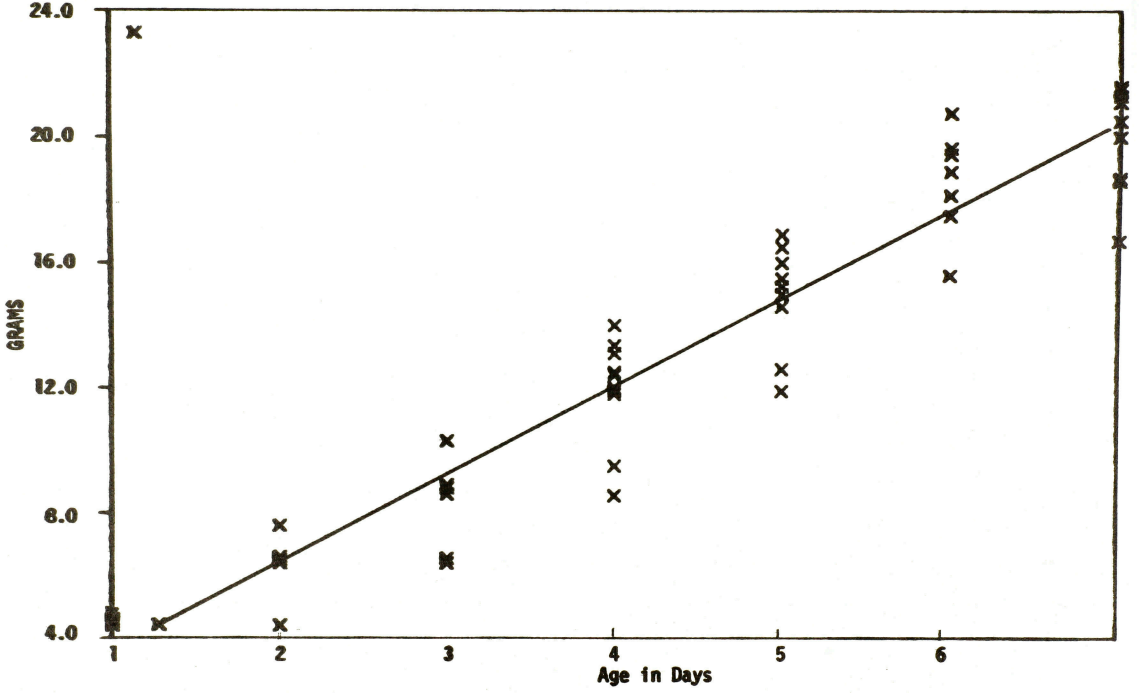


Figure 12. Development of Young

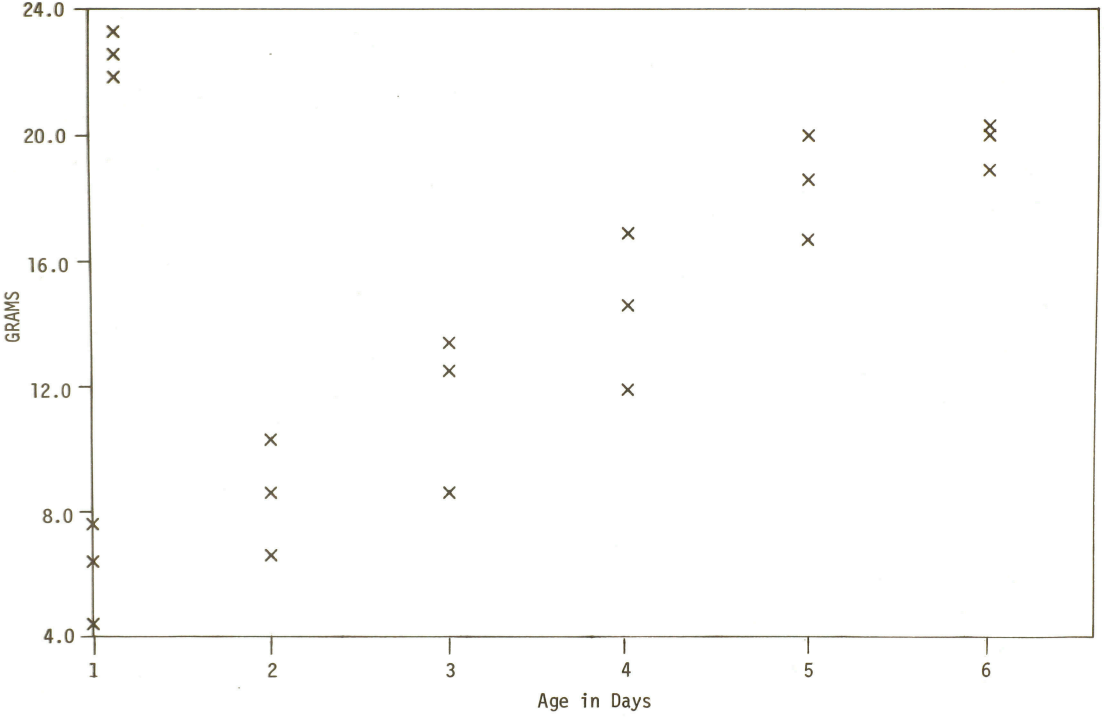


Figure 13. Development of Young in Nest One

Fledglings

Fledging occurs about 10 days after hatching, at which time the young bird has reached a weight of near 20 grams. The body becomes completely covered with feathers and the flight feathers are almost completely out of their sheath-like covering. It is doubtful that the young birds could fly to any great distance or height at this early date but nonetheless they leave the nest. During the early days after leaving the nest the young birds are seldom or never seen. They remain in the thickets close to the nest site. At this time I would think the young birds would be very vulnerable to any mammalian predators living there and would certainly be victim to any harsh or inclement weather. The young maintain contact with their parents by a weak call or chirp. The adults return this call and thus contact is maintained within the entire group. The adults feed the young for an undetermined length of time after they leave the nest. It is very difficult to determine to what extent the young are cared for, but for a period of 2 weeks after fledging the adults were actively carrying food into the nesting area. During this time I would walk through the brush thickets trying to flush the young. This met with only meager success. The young birds seemed very well adapted to running and hiding in the brush. On July 6 I saw the first immature bird which was not trying to hide in the undergrowth. I was sitting under the large tree in territory 7 when a young towhee flew into the tree a few feet away. It was accompanied by an adult which upon seeing me flew away with the young bird following.

From this, it would seem that the young are cared for for a considerable length of time after fledging. This young bird must have fledged near the 24th of June yet was still being cared for on the 6th of July. This incident also shows that the young birds lack a knowledge of their parents' territorial borders. Both adult and young birds were in a territory occupied by another pair of towhees which I could also see at the time. When the young towhee is newly fledged it stays in its parent's territory because of its immobility, but once it learns to fly, it shows its lack of knowledge by flying into another territory.

The call given by the young towhees shortly after they leave the nest is a simple chirp, but they later develop the mewing call of the adults. Other calls or song development were not observed but Rockwell and Wetmore (1914:327) stated that the call of young birds could not be distinguished from that of the young of Pipilo erythrophthalmus montanus Swarth.

Juvenal Plumage

The nestling or juvenal plumage is marked with dusky blackish streaks on the breast and belly with the throat being white. The adult characteristics of a mustachial stripe and short superciliary line are evident. The crown, including the forehead, to the nape is streaked with a dark brown and olive undercolor. This color pattern extends on to the back in most specimens. The primaries and secondaries are characteristically adult, but the

secondaries have a brownish cast toward the margins, unlike the solid gray of the adult.

The post-juvenal molt begins in late July, with the replacement of the juvenal feathers on the belly, flanks, chest and back. Specimens collected in early September show the complete replacement of the body feathers and the beginning of the replacement of the feathers of the head. The primaries, secondaries, primary coverts, and rectrices are not replaced in this, the post-juvenal molt.

There is a recognizable difference between the juvenal male and female. After the post-juvenal molt the male resembles the adult, but the juvenal female has the chestnut cap concealed by the grayish tips of the feathers. During the prenuptial or spring molt the throat and anterior parts of the head receive new feathers. The slight wearing of the gray tips of the juvenal female's crown exposes the adult chestnut at this time.

The juvenal plumage may help to solve the relationship of the Green-tailed Towhee to the genus Pipilo. Parkes (1957:499) reported a similarity between the two groups. "The juvenal plumage of Chlorurus conforms precisely to the Pipilo pattern. Uniformly streaked above, with no indication of the contrast in color between back and crown of the adult; unstreaked on the throat (which is white in the adult), streaked on the remainder of the underparts, with the markings heaviest across the chest, where the adult has a gray band with poorly-defined posterior edge."

Reproductive Success

During the summers of 1969 and 1970 ten nests were found and observed. Of these, eight were successful as far as hatching is concerned. Nest number 3 had one egg when I first found it and no other eggs were laid. Nest number 4 was destroyed by inclement weather. Of the eight remaining, four had three eggs and the other four had four eggs. All eggs in the eight undisturbed nests hatched, but of the total number of eggs laid, only 84% hatched.

The greatest mortality or major known loss of birds occurred during the nestling period. During this time five of the remaining eight nests and contents were destroyed. The loss of young is depicted in graphical form in Figure 14. During the nestling period 66% of the young were taken from the nest by predators before fledging. Only nine birds were known to have fledged. This was 28% of the total eggs laid. Only 30% of the nesting females were able to raise a clutch that fledged. Of these, one was a second nesting.

Information bearing on other localities and during different years is non-existent so I cannot generalize on this high rate of nestling mortality. It is not known whether it is this high throughout the Green-tailed Towhee range. In addition, some of the young would surely be lost after fledging. A result of only nine fledging for 14 adults would hardly sustain the population. This high rate of nestling mortality may have been abnormal because my activities may have led potential predators to the

nests. Walking through the surrounding vegetation, no matter how varied the path, caused some disturbance. But in addition, there appeared to be inherent factors that make for high mortality as a natural phenomenon. One item is the activity of the adults themselves. During incubation the female remains on the nest making relatively few trips to and from it but after hatching, both parents make many feeding trips to the nest. This increased activity and the activity of the young in the nest may account for a high rate of nestling loss during this period.

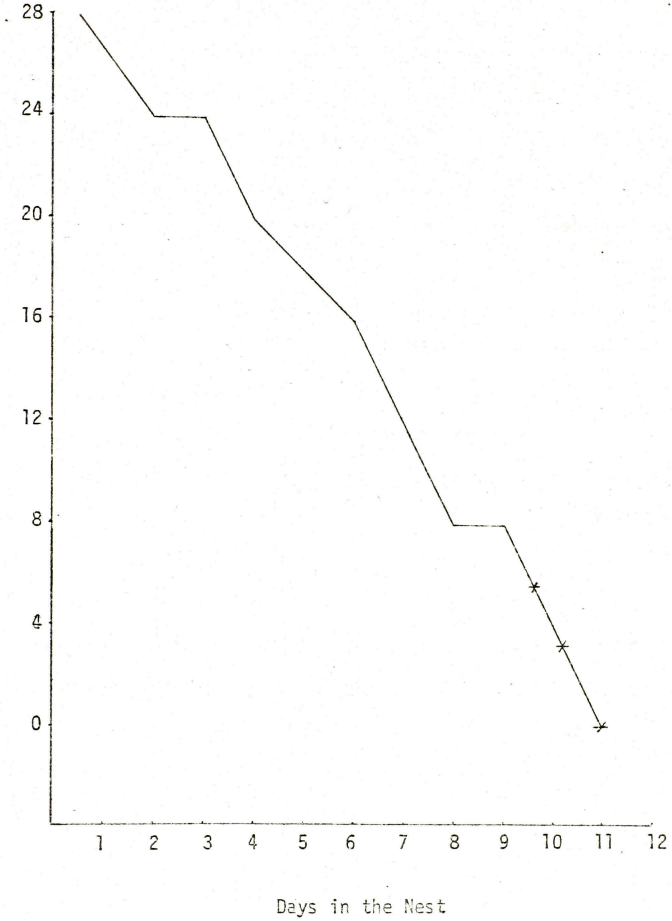


Figure 14. The survival curve for nestlings. Those over nine days fledged successfully. Those indicated with an asterisk indicate fledged birds.

Summary and Conclusions

Field studies of the Green-tailed Towhee were conducted during the summers of 1969 and 1970. Birds were studied from the time of their arrival in the breeding area until fall migration. The study area was located in Mountain Dell Canyon, 15 miles east of Salt Lake City, Utah at an elevation of 6,000 feet.

The Green-tailed Towhee's breeding range is from southwestern and central Oregon, southeastern Washington, the southern portions of Idaho, Montana and Wyoming, through the interior mountains of California, all of Nevada and Utah to central Arizona and southern New Mexico. During the breeding season the birds are found in the Transition zone and to some extent the lower parts of the Canadian zone. The winter range extends from southern California, Arizona and Texas south to central Mexico.

The Green-tailed Towhee displays territoriality but an added feature is the establishment of pseudo-territories or pre-territories in the last phases of their migration while still not on their breeding grounds. These are established in resting areas and are maintained briefly, at most for only a day. This appears to facilitate the rapid establishment of true territories when the bird finally reaches its breeding area.

The breeding territory is set up and maintained by the males. Proclamation is by constant singing in the early stages of the mating cycle but drops off sharply after mating and nest construction. Courtship is a relatively short process, since mating and copulation occur shortly after the female arrives in the territory. Territories were established in a scrub-type vegetation

of uniform configuration and height, consisting primarily of sage and bitterbrush. The height of the latter seldom exceeded 2 meters.

The building of the nest takes two days and is done exlusively by the female. During this time the male sings less often and for shorter periods of time. Copulation may continue during the nest building period, but ceases with the commencement of egg laying. The average clutch size was 3.2 eggs in the nests that I studied. The laying season begins late in May. If a first set of eggs is destroyed a renesting may occur, in which case nesting continues into late June. Eggs may occur in nests until mid-July.

During incubation, which is done entirely by the female, singing on the part of the male continues to decrease. The incubation period was twelve days for the nests studied.

Hatching of the eggs most often involves two of three eggs hatching at the same time and the third hatching the following day.

When hatched, the young are weak and helpless and are covered with a blackish down. Development in the nest takes 10 days, after which the young leave the nest. Weight increases among nestlings were very uneven during the first days of nestling life, but before fledging, weights were fairly even, leveling off around 20 grams. Fledglings are fed by both parents for an undetermined length of time.

After fledging, the parents did not renest, but three pairs that had their nests destroyed constructed new nests and laid eggs, of which one successfully raised a brood.

There is a high rate of mortality at the nestling stages. Five of the ten nests studied were destroyed by predators before the young could fledge but it was not definitely determined which predators were involved. Magpies were probably responsible for the loss of young, for they were abundant in the general area and were often seen in the vicinity of the nest.

The food of the Green-tailed Towhee is a mixture of plant and animal matter. Thus, 57.5% of animal content includes weevils, ground beetles, darkling beetles and insect larvae. Plant food consists mainly of weed seeds (approximately 42.5%). The nestlings were fed on insect larvae and grubs.

Both parents practice coprophagy, which is done to maintain the cleanliness of the nest. This behavior is not unique, for it has been observed in other birds, including the Rufous-sided Towhee (Pipilo erythrophthalmus).

Certain lines of evidence support the placing of the Green-tailed Towhee in the genus Pipilo, namely coprophagy, the juvenal plumage, flight patterns, type of habitat chosen, and feeding patterns. These are all very similar to the Rufous-sided Towhee.

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Appendix A

Plant species in the study area.

Species	Percent of occurrence in the 26 quadrats
Achillea millefolium (Nutt.) Piper	92
Agropyron cristatum (L.) Gaertn	96
Allium spp. L.	31
Arabis holboellii Hornem.	08
Artemisia ludoviciana Nutt.	15
Artemisia tridentata Nutt.	31
Astragalus cibarius Sheld.	08
Balsamorhiza macrophylla Nutt.	38
Chrysothamnus spp. Nutt.	12
Collomia linearis Nutt.	08
Comandra umbellata (L.) Nutt.	15
Elymus spp. L.	19
Eriogonum heracleoides Nutt.	31
Galium aparine L.	04
Lactuca spp. L.	38
Lithophragma spp. Nutt.	38
Lithospermum arvenses L.	46
Lupinus spp. L.	12
Berberis repens Lindl.	24

Plant species in the study area.

Species	Percent of occurrence in the 26 quadrats
Mosses	15
Purshia tridentata (Pursh)DC.	08
Rosa woodsii Lindl.	04
Senecio integerrimus Nutt.	38
Viola purpurea Kellogg	15
Wyethia emplexicaulis Nutt.	04
Zigadenus spp. Michx.	04
Orogenia linearifolia S. Wats.	19

Appendix B

Birds observed in Mountain Dell Canyon.

Scientific Name	Status	Activity
Cathartes aura (Linnaeus)	Casual	Soaring
Buteo jamaicensis (Gmelin)	Casual	Hunting
Buteo swainsoni Bonaparte	Infrequent	Hunting
Aquila chrysaetos (Linnaeus)	Casual	Soaring
Circus cyaneus (Linnaeus)	Casual	Hunting
Falco mexicanus Schlegel	Infrequent	Mating Display
Falco sparverius Linnaeus	Common	Hunting
Centrocercus urophasianus (Bonaparte)	Infrequent	Feeding
Zenaidura macroura (Linnaeus)	Casual	Flying
Selasphorus platycercus Swainson	Casual	Feeding
Colaptes auratus (Gmelin)	Casual	Flying
Pica pica (Linnaeus)	Common	Feeding
Turdus migratorius Linnaeus	Common	Flying
Sturnus vulgaris Linnaeus	Common	Flying
Piranga ludoviciana (Wilson)	Infrequent	Flying
Passerina amoena (Say)	Common	Nesting
Spinus tristis (Linnaeus)	Infrequent	Feeding
Pipilo erythrophthalmus (Linnaeus)	Infrequent	Feeding
Spizella breweri Cassin	Common	Nesting

Appendix C

Mammals captured or observed in study area.

Species	Total number captured
Eutamias umbrinus (Allen)	76
Peromyscus maniculatus (Wagner)	64
Citellus variegatus (Erxleben)	29
Sorex vagrans Baird	27
Microtus montanus (Peale)	10
Citellus armatus (Kennicott)	2
Spilogale putorius (Linnaeus)	2
Mephitis mephitis (Schreber)	2 (1 roadkill)
Clethrionomys gapperi (Vigors)	2
Mustela frenata Lichtenstein	2 (roadkills)
Microtus longicaudus (Merriam)	1
Taxidea taxus (Schreber)	1
Thomomys talpoides (Richardson)	1

	Total number observed
Odocoileus hemionus (Rafinesque)	100+5
Cervus canadensis Erxleben	5
Felis catus Linnaeus	1
Sylvilagus nuttalli (Bachman)	1